Department of Energy Mini-Review of the
Tevatron Run II Luminosity Upgrades

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PLACE: Fermi National Accelerator Laboratory

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SUMMARY:

The purpose of the review was to assess the progress in completing the resource-loaded plan for the Run II Luminosity Upgrades submitted in January 2004, and to evaluate the general performance of the management team leading the Run II luminosity improvement effort.

Overall, the Committee was impressed with the technical progress in implementing the Plan strategies and resultant improvements in luminosity. As of July 2004, the Run II Upgrades are 38% complete. The Committee believes Laboratory management to be giving appropriate priority to Run II Upgrade activities and found them to be effective in coordinating the wide array of Run II activities across the Laboratory.

TECHNICAL:

The Committee was impressed with improvements in the luminosity performance of the Tevatron since the last review in February 2004. Peak luminosity increased from 0.6×10^{32} cm^{-2} sec^{-1} in February to 1.0×10^{32} cm^{-2} sec^{-1} in August. The "Design" Luminosity goal for FY2004 was exceeded by 12%, due to the improved performance. The integrated luminosity per week has nearly doubled from that achieved in FY2003. It is very impressive to see that that level of store-hours per week was largely maintained throughout the FY2004 running period. Part of the enhanced peak luminosity performance is due to a new "dual-source" mode of operation in which pbars from both the Accumulator and the Recycler are utilized for Tevatron stores.

Incorporation of remaining planned upgrade elements are progressing well. "Phase II" Tevatron operations will commence after the 2004 shutdown. The main objective of this phase is the incorporation of slip-stacking into Main Injector operations in order to double the proton intensity on the pbar production target. Successful tests of slip-stacking have been performed at total proton intensities of 7.0×10^{12}, which is close to the design goal of 8.0×10^{12}.

The milestone for preparing the Recycler for operation was achieved ahead of schedule. The Recycler is now incorporated into operations in a mixed mode in which Recycler pbars supplement those from the Accumulator. The committee applauds the incorporation of the Recycler into operations, as this will both enhance the understanding of the Recycler and its

limitations, and also provide a luminosity boost. With the electron cooling R&D program finished, the cooling hardware installation is now in progress. New low-beta IP optics were installed and resulted in improved luminosity performance; the alignment campaign continues to show good progress and has resulted in improved Tevatron performance; the Tevatron beam position monitor project continues to make progress and remains on schedule.

While the improvement in luminosity performance is impressive, it resulted from a number of improvements to (and imaginative solutions in) the existing facility and its operations, but not yet from the pbar stacking rate. The ten store average pbar zero-stack stacking rate is 12.7×10^{10}/hour, compared to a design goal of 18×10^{10}/hour and a base goal of 13.7×10^{10}/hour. At the February 2004 review, the corresponding rate was 10.9×10^{10}/hour.

The major shortcoming is in the cycle time, where the optimal achieved cycle time is 2.2 sec compared to the goal of 1.7 sec. There is a significant drop in pbar/proton production yield when the cycle time is varied from 3.5 sec to 2.0 sec, most likely due to Debuncher to Accumulator transfer efficiencies associated with the D-A transfer line acceptance, betatron mismatch, or too large emittances. The exact cause is uncertain partly due to lack of calibrated transverse emittance measurement instrumentation in the Debuncher.

Two shifts per week have been allocated for pbar source studies to improve and understand the pbar stacking rates, with 30-50% of this time devoted to beam-based aperture, alignment and obstacle finding in the Debuncher and AP2 line. Although effort is being spent on this important issue, this work has yet to yield an increase in aperture since the last review. The committee is concerned with the lack of reported progress in this area as a major part of the future stacking rate improvement is from the anticipated aperture increase in antiproton collection aperture.

Significant progress was reported in the Debuncher momentum cooling. The replacement of the Bulk Acoustic Wave notch filters with optical filters having lower dispersion, together with gain ramping, has reduced the energy spread from 8 MeV to less than 5 MeV.

After the installation of a 53 MHz turn-by-turn system, a slope of the RF voltage of the Debuncher barrier bucket outside the bucket was identified. This results in longitudinal blow-up of 10-30 percent upon transfer to the accumulator. This issue will be remedied during the shutdown.

The Committee noted a significant improvement in understanding of limitations to the pbar stacking rate made possible by improved instrumentation and diagnostics capabilities, and study time.

The Committee was concerned about Tevatron operation at full Run-II design intensities. This will bring the Tevatron into the strong-strong beam-beam regime, with all the accompanying complications that will result. The parasitic beam-beam effects will become more severe, which places increased importance on the beam separation and helix design. The Committee would like more details at the next review on the design of the separation helix for full Run-II intensities, and on expected impact of parasitic and primary beam-beam interactions at the highest intensities.

As regards the Run II luminosity projections, the committee finds the "Design" plan to be aggressive, but achievable. The more conservative assumption on ramp-up of integrated luminosity following a shutdown is reasonable based on operating experience.

Recommendations

1. Continue to provide study time for and priority to AP2 and Debuncher aperture studies.
2. Continue to improve instrumentation to better understand performance limitations, e.g., scraper and beamloss scintillators in Debuncher and Accumulator for calibrated emittance measurements.
3. Continue to study and improve cooling systems and beam transport (equalizer improvements, gain optimizations, D to A line optics and aperture).
4. Devote some machine studies time to longer-term beam dynamics issues in the Tevatron, such as beam-beam studies and studies of separation criteria.
5. Continue to provide study time for pbar source and Booster limitations.

COST, SCHEDULE, AND MANAGEMENT:

The Run II Luminosity Upgrade Plan was updated on July 1, 2004. This update incorporated the phased implementation strategy for the antiproton stacking upgrades and a change to the projected luminosity profile to incorporate a more conservative shutdown recovery slope for each phase. The projected luminosity through FY 2009 is essentially unchanged (Design 8.2 fb^{-1}, base 4.1 fb^{-1}).

The Upgrades cost increased by $1,045K for Material and Services and $1,625K for Salary Wages and Fringe. It is reported that the currently available amount of contingency is 50 percent of remaining costs. As of the end of July 2004, the Run II Luminosity Upgrades are 38 percent complete.

Monthly reports on cost and schedule status are prepared and submitted to DOE. A new cost reporting system is underway to address the difficulty in collecting labor costs across Divisions. A new WBS element structure will be directly linked to organizational cost codes to allow for cross-divisional cost roll-ups. Additional resources have been assigned to the Run II project office to aid in scheduling area and for developing the necessary management tools.

Laboratory management continues to give appropriate priority to Run II activities. The Run II management team is coordinating upgrade activities across the Laboratory well. The practice of internal technical peer reviews contribute to the successful implementation of planned improvements, and the Committee supports their continued use.

The new luminosity projections appear reasonable.

Recommendation

1. The Office of High Energy Physics, the Fermi Site Office and Fermilab should work together to make tracking and reporting of Run II activities efficient, timely and useful to all parties.